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BUBBLE DETECTOR FOR INKJET RECORDING HEAD
[Inkujetto kiroku heddo no kiho kenshutsu sochi]

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Specification

1. Title of the Invention

Bubble Detector for Inkjet Recording Head

2. Claim (Amended June 28, 1993)

A bubble detector for an inkjet recording head, wherein the inkjet recording head comprises an ink chamber and a piezo-electric element installed in one of the surfaces composing the ink chamber, and wherein the bubble detector has a means for detecting the presence or absence of bubbles in the ink chamber using the oscillating waveforms generated by the piezo-electric element.

3. Detailed Description of the Invention

(Industrial Field of Application) (Amended June 28, 1993)

The present invention relates to an inkjet recording head used in an inkjet recording device and, more specifically, to a bubble detector for an inkjet recording head.

(Prior Art)

The inkjet recording head used in current inkjet printers contains a piezo-electric element operated by pulses to generate an electrostriction phenomenon that changes the volume of the ink chamber inside the inkjet head, increases the pressure on the ink inside the ink chamber, and jets the ink from the nozzle. (These heads usually have an ink channel consisting at the very least of a tube or a channel formed in laminated substrates with facing grooves. The piezo-electric element is installed surrounding the tube or on the outside of a substrate positioned with respect to the grooves.

The groove corresponding to the piezo-electric element communicates with the ink chamber and nozzle in the ink chamber.)

(Problem to be Solved by the Invention)

When bubbles occur in the ink chamber or the ink chamber runs low on ink, the ink droplet jetting performance of the nozzle decreases significantly. Ink droplets are not jetted at all if the nozzle becomes clogged. When an inkjet printer is used under these circumstances, all of the print data is not printed and printing mistakes occur.

The purpose of the present invention is to overcome these problems by providing a bubble detector that is able to detect bubbles in the ink chamber and to detect whether the ink chamber is low on ink.

(Means of Solving the Problem)

The present invention uses a drive circuit for a piezo-electric element and an oscillating waveform rectifying circuit when the piezo-electric element is being operated to detect the frequency of the repeated oscillating waveform and determine whether or not there are bubbles in the ink chamber.

(Working Examples)

The following is an explanation of a working example of the present invention with reference to the drawings.

As shown in FIG 3, the inkjet recording head [28] has an ink chamber [23] formed inside, and an ink reserver [24] is connected to the ink chamber [23] at the rear. A nozzle [25] is formed at the

front of the ink chamber [23]. There is an oscillating plate [26] at the top of the ink chamber [23], and an electrode shared with the piezo-electric element. The piezo-electric element [9] is also formed in the top.

As shown in FIG 1, the output terminal of the buffer [1] is connected to the base of an NPN transistor [4], and the emitter of the NPN transistor [4] is grounded. When the collector of the NPN transistor [4] is connected to a high-voltage power source V_H via bias resistance [13], it is also connected to one of the electrodes of the piezo-electric element [9] via discharge resistance [14]. The electrode on the opposite end of the piezo-electric element [9] is grounded. One of the electrodes of the piezo-electric element [9] is connected to the collector of a PNP transistor [6] via charge resistance [15].

The output terminal of the buffer [2] is connected to the base of the NPN transistor [5], and the emitter of the NPN transistor [5] is grounded. When the collector of the NPN transistor [5] is connected to the high-voltage power source V_H via resistance [12], it is also connected to the base of the PNP transistor [6]. The buffers [1, 2], the transistors [4, 5, 6] and the resistance [12-15] constitute the drive circuit.

A series circuit consisting of a capacitor [10] and resistance [16] is connected in parallel to the piezo-electric element [9]. Because the capacitor [10] and the resistance [16] form a filter, the contact point is connected to the anode of a diode [11]. When the

cathode of the diode [11] is connected to the base of the NPN transistor [7], it is also connected to the emitter of an NPN transistor [7] via resistance [17]. The emitter of the NPN transistor [7] is grounded via resistance [18]. The collector of the NPN transistor [7] is connected to logic power source Vcc. The emitter of the NPN transistor [7] is connected to the base of an NPN transistor [8] via resistance [19], and the base of the NPN transistor [8] is connected to the emitter of the NPN transistor [8] via resistance [20]. The emitter of the NPN transistor [8] is grounded. When the collector of the NPN transistor [8] is connected to the input terminal of the output buffer [3], it is also connected to the logic power source Vcc via resistance [21]. The detection signals are outputted from the output terminal of the output buffer [3]. The buffer [3], the transistors [7, 8], the diode [11], the capacitor [10] and the resistance [16-21] constitute the oscillating waveform detection circuit.

In an inkjet device with this configuration, the high-voltage power source V_H is initially connected to one terminal of the piezo-electric element [9] via resistance [13, 14] so the voltage V_0 of this terminal of the piezo-electric element [9] is essentially V_H. Initially, the piezo-electric element [9] is distorted and the volume of the ink chamber [~~25~~ 23] is small. When ink droplets are jetted, pulse voltage DPW with the predetermined pulse width t_1 shown in FIG 2 is applied to the input terminal of the buffer [1], transistor [4] is turned on, and the charge stored in piezo-electric element [9] is

discharged via discharge resistance [14]. At this time, the piezo-electric element [9] returns to the distorted state, the volume of the ink chamber [23] increases, and ink flows from the ink reserver [24] in the rear to the ink chamber [23]. When the predetermined pulse width is complete, tw standby occurs until the transistor [4] is completely off. Pulse voltage CPW with the predetermined pulse width t_2 shown in FIG 2 is then applied to the input terminal of buffer [2]. Transistor [5] is turned off, and the base potential of the transistor [6] drops below the emitter potential of transistor [6]. Transistor [6] is simultaneously turned off, and the charge is applied from the high-power source V_H to the piezo-electric element [9] via charge resistance [15]. The piezo-electric element [9] is distorted, the volume of the ink chamber [23] is reduced, and an ink droplet is discharged from the nozzle [25]. This operation is repeated to continuously discharge ink. The repeat cycle T is determined by the specific response frequency of the head.

When piezo-electric element drive waveform V_0 is measured during continuous operation, piezo-electric element waveform V_0 occurs for a give cycle after the piezo-electric element has been distorted as shown in FIG 2. If bubbles occurs in the ink chamber [23] or it runs POW out of ink, the change in the piezo-electric element impedance creates an oscillating waveform that takes longer than the normal period and this is detected. Because the oscillating waveform frequency is abnormal or greater than normal, this oscillating

waveform frequency can be detected to determine whether there are bubbles in the ink chamber [2] or whether it has run out of ink.

FIG 4 through FIG 6 show the waveforms detected by the detection circuit in FIG 1 from the piezo-electric element drive waveform V_0. FIG 4 shows the situation when there are no bubbles in the ink chamber. FIG 4 (a) shows the piezo-electric element drive waveform V_0. The DC component of the piezo-electric element drive waveform V_0 is cut out by a filter consisting of capacitor [10] and resistance [16] to produce the oscillating waveform at the anode end of the diode [11] shown in FIG 4 (b). The positive component is extracted by diode [11] to obtain the waveform in FIG 4 (c). The emitter follower consisting of transmitter [7] and resistance [17, 18] lowers the input impedance. The waveform rectifying circuit consisting of transistor [8], resistance [19, 20, 21] and buffer [3] generate the detection waveform in FIG 4 (d). The period of time T_2 from the first burst to the second burst of the detection waveform is compared to determine whether it falls within the normal time period (i.e., when there are no bubbles).

FIG 5 shows the situation where there are bubbles in the ink chamber. FIG 5 (a) shows the piezo-electric element drive waveform V_0. The DC component of the piezo-electric element drive waveform V_0 is cut out by a filter consisting of capacitor [10] and resistance [16] to produce the oscillating waveform at the anode end of the diode [11] shown in FIG 5 (b). The positive component is extracted by diode [11] to obtain the waveform in FIG 5 (c). The emitter follower

consisting of transmitter [7] and resistance [17, 18] lowers the input impedance. The waveform rectifying circuit consisting of transistor [8], resistance [19-21] and buffer [3] generate the detection waveform in FIG 5 (d). The period of time T_2 from the first burst to the second burst of the detection waveform is compared to determine whether it falls within the normal time period.

FIG 6 shows the situation when ink is running low. The DC portion of the piezo-electric element operating waveform V_0 is cut by the filter consisting of the capacitor [10] and the resistance [16] as shown in FIG 6 (a) to produce the oscillating waveform shown in FIG 6 (b) at the anode end of the diode [11]. The positive portion is taken out by the diode [11] to product the waveform shown in FIG 6 (c). Transistor [7] and resistance [17, 18] are used to constitute an emitter follower, which lowers the input impedance. Transistor [8], resistance [19-21] and buffer [3] constitute a waveform rectifying circuit, which creates the detection waveform shown in FIG 6 (d). The time T_2 from the first burst to the second burst of the detection waveform is compared to determine if it has occurred within the normal time period.

10 As explained in FIG 4 through FIG 6, the normal T_2 is set initially, normal T_2 is stored in a processor such as a microprocessor, the repeat time for the detection waveform during the detection process is compared to the normal T_2, and the presence or absence of bubbles and the presence or absence of ink are readily detected. When a malfunction is detected, the printer device

~~automatically performs inkjet head cleaning~~. The bubbles are removed from the ink chamber, the chamber is filled with ink, and the inkjet head is operated. When normal, non-detection operation has been verified, normal operation is repeated. In this way, automatic bubble detection and cleaning can be performed.

(Effect of the Invention)

As explained above, by repeating the oscillating waveform of the piezo-electric element and detecting the frequency, the present invention can detect whether or not there are bubbles in the ink chamber, whether or not the ink chamber is empty and whether or not the nozzle is clogged. Dot removal detection can be performed, malfunctions such as printing mistakes can be prevented, and initial detection is extremely effective. Because the repeated oscillating waveform frequency is detected, the oscillating waveform amplitude can be compared to the operating voltage and the oscillating cycle does not change even if the operating voltage of the printing head has to be changed due to the temperature characteristics and other factors. As a result, the detection device is highly reliable.

4. Brief Explanation of the Drawings

FIG 1 is a circuit diagram of the bubble detector in a working example of the present invention. FIG 2 is a timing signal chart for the operating method of the same example. FIG 3 is a cross-sectional view of an inkjet head groove. FIG 4 (a), (b), (c) and (d) are timing signal charts used to explain the detection circuit in FIG 1 before bubbles occur. FIG 5 (a), (b), (c) and (d) are timing signal charts

used to explain the detection circuit in FIG 1 when bubbles occur. FIG 6 (a), (b), (c) and (d) are timing signal charts used to explain the detection circuit in FIG 1 when the chamber runs out of ink.

Driving ckt

FIG 1

Oscillating waveform detection ckt

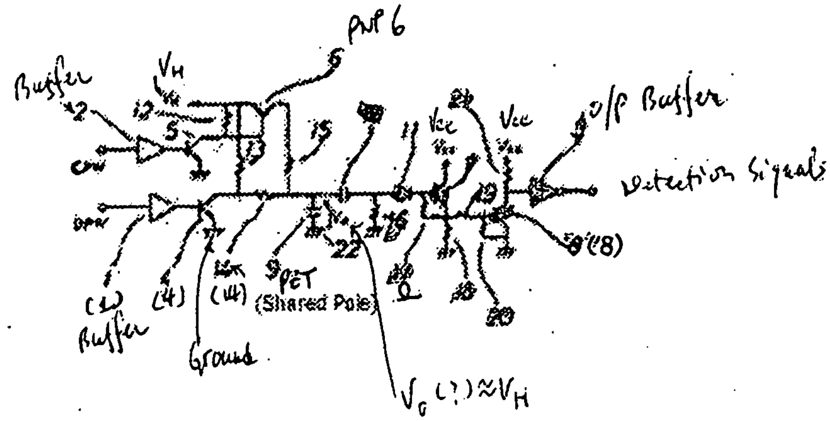
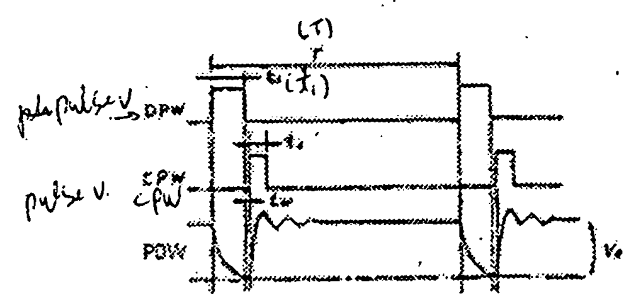


FIG 2



PDW - Piezoelectric Drive Waveform

FIG 3

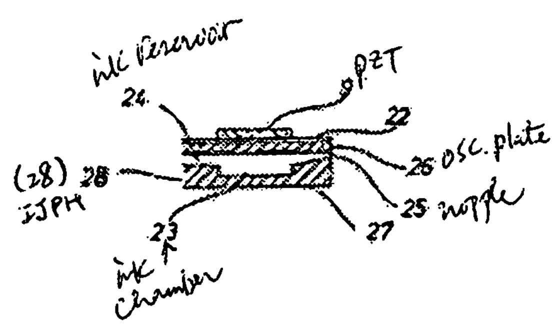


FIG 4

NO Bubble

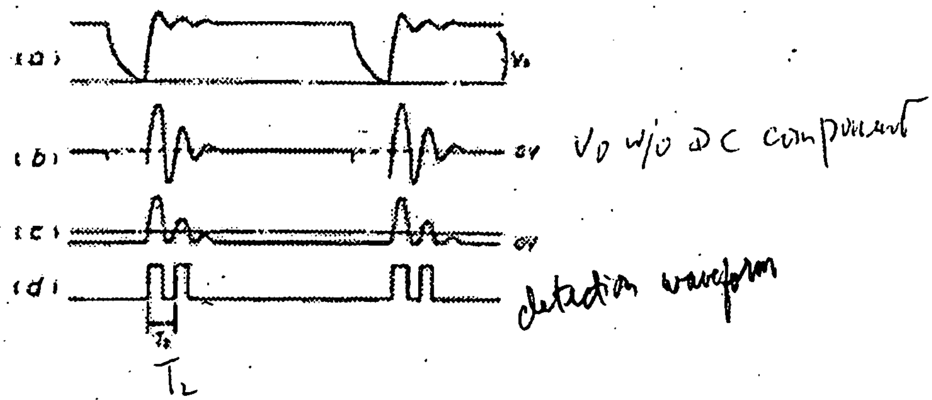


FIG 5

Bubble(s)

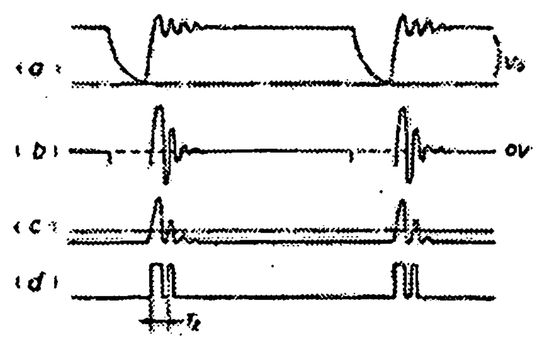
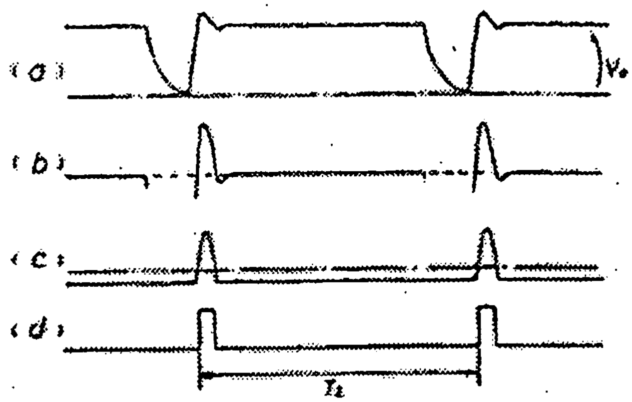


FIG 6



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